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FINITE ELEMENT SIMULATION OF BRIDGING VEIN RUPTURE

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1 Introduction

Bridging veins (BV) drain the venous blood from the cerebral cortex into the superior sagittal sinus (SSS) and doing so they bridge the subdural space. Rupture of these bridging veins is responsible of 1/3 of the cases of Acute Subdural Hematoma (ASDH), a head lesion with a mortality rate of 30% to 90% [Depreitere2004, Depreitere2006].

Uniaxial tensile tests on BVs have provided information on the strain at which these veins fail [Lee 1989, Baeck 2013]. To find how these uniaxial failure values relate to actual real-life loading situations, head rotational tolerance criteria have been defined. On the one hand, these criteria can be defined based on cadaveric head tests [Depreitere2006]. On the other hand, finite element (FE) simulations can be performed. The goal of this study is to compare the rotational tolerance curve that was found based on cadaver testing by Depreitere et al., with FE simulations.

2 Materials and methods

One of the most advanced BV models so far is integrated in the KTH head model, with the BVs represented as linear spring-damper elements. A failure criterion is added to the material description of the BV in the KTH head model based on the uniaxial tensile strain values upon failure, obtained in experiments performed by Baeck et al., 2013. Next, the different combinations of rotational accelerations and pulse durations measured during the cadaver head experiments are used as input for the FE head model. This is done by means of a boundary prescribed motion where the head is restrained to only translate and rotate in the sagittal plane. Linear and rotational acceleration are then applied according to the measurement data of the experiments. This procedure is repeated for all the experiments where BV rupture occurred.

The computed strain of the BV is monitored to verify whether it exceeds the failure criterion. It is checked whether this corresponds to the failure observed in the experiments.

3 Results

A finite element simulation with a rotational acceleration of 15 $krad/s^2$, 270G translational acceleration delivered to the center of mass of the head and 5 ms pulse duration showed to be sufficient to cause BV rupture. This corresponds to the experimentally observed rupture at the same acceleration level. After this promising result, future work will consist of simulating the whole range of experiments conducted by Depreitere et al. and to compare the results with their tolerance curve. This will allow us to check the biofidelity of the FE head model in these cases.

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